Seasonal Fluctuations of the Mesofauna in Soil Under Kikuyu Grass

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1. INTRODUCTION

The South African soil fauna is practically unknown and although this situation was somewhat augmented during the last few years vast territories in the country are still unexplored. This state of affairs also prevails in the temperate regions of the Souhern Hemisphere as well as in all the tropical and subtropical regions. Until recently the majority of soil zoological publications referred to northern and central Europe but at present a considerable upstart of the science of soil zoology is witnessed in other parts of the world.

Of the different kinds of animals constituting the soil mesofauna the most important are the arthropods. Because it is very difficult to attain the the same degree of accuracy of identification with all animal groups which are collected, detailed identification of the total material collected during the present investigation was not attenpted. The majority of the Mesostigmata, Trombidiformes and Oribatei were determined down to the generic or specific level whereas the Collembola and other arthropods were treated as group. The unidentified species of mites are probably all new to science and will be described in separate papers.

The investigation of the soil under kikuyu grass forms part of a large project in the Potchefstroom area which includes studies of the mesofauna of pasture soils, soils under *Eragrostis* grass and *Acacia* trees, and soils in a crop rotation system. These data are, however, not yet available for comparison but the results obtained should furnish a basis for subsequent investigations.

2. SAMPLING AREA

The sampling plot for this investigation was selected on the farm of the Potchefstroom Agricultural Research Institute. Potchefstroom (lat. 26° 44′ S, long. 27° 05′ E; mean height above sea level 4430 ft) is situated on the banks of the Mooi River in the Western Transvaal, which forms part of the inland plateau. This area is characterised by fairly shallow undulating plains with an altitude varying between 4,000 and 5,000 ft.

The soil types vary in different parts of the district, but gravelly and shallow sandy clay loams prevail. Patches of sandy loam and black or brown turf are, however, also found. The soils of the Agricultural Research Institute consist mainly of reddish brown sandy clay loam and partly of dark brown clay types.

The high altitude and the latitude position largely determine the climate of Potchefstroom. Like the greater part of the South African sub-continent, the Potchefstroom area lies in the belt of the permanent south East Trade

Winds. As the axis of this belt shifts north and south seasonally with the sun, relatively low atmospheric pressure occurs over the interior in the summer and high atmospheric pressure in the winter. Warm, moist, equatorial air moves southwards along the east side of a low pressure system and causes predominantly north westerly winds and summer rains over the Western Transvaal. Due to the high pressure system in the winter, the weather is fine, dry and cold at night. Potchefstroom lies just in the boundary area between the semi-arid climates or middle latitude steppes, and the humid mesothermal climates with dry winters and hot summers.

According to observations made at the Potchefstroom Weather Station from 1906 - 1955 (Baier, 1963) wide daily fluctuations in air temperatures of approximately 19° C in winter and 14° C in summer occur. During the year the monthly average maximum air temperatures range from 19.1° C to 29.5° C and the minimum temperatures from — 0.6° C to 15.3° C. The highest maximum ever recorded was 39.2° C and the lowest minimum — 10.2° C. The monthly means show a rapid increase of 4.0° C from August to September, and a drop of 4.0° from April to May.

The frost-free period, as recorded at 2 inches above grass, extends from October 10 to April 25, i.e. over 209 days. The soil temperatures at depths from 1″ to 4″ range from 11.4° C to 11.8° C in June to 27.1 C° to 28.3° C in January and February. From October to March the average temperatures are highest near the soil surface and decrease with depth. In winter the temperatures are approximately the same between 1″ and 8″, but they increase considerably from 1 ft. to 6 ft. It appears that soil temperatures are more closely related to sunshine duration than to air temperatures, because the fluctuations of the former from year to year are also fairly small under the local conditions.

The average atmospheric pressure is highest in July and lowest in January, the annual average being 872.6 mb. Like other places situated in the belt of high atmospheric pressure, and at a similar elevation, Potchefstroom enjoys 8 to 9 hours of daily sunshine throughout the year. The extremely low relative humidity at 2 p.m. (as recorded at the weather station) is a distinct feature of this area. The monthly averages range from 26 per cent in September and October to 48 per cent in February, but the daily readings at 2 p.m. frequently remain below 10 per cent in winter.

The average monthly rainfall increases from 7.4 mm in June to 107 mm in January. The monthly rainfall exceeds 100 mm during December, January and February, and remains below 10 mm during June, July and August. Because the mean monthly totals increase from 16.5 mm in September to 49.6 mm in October and drop from 84.2 mm in March to 38.8 mm in April, October can be regarded as the beginning and March as the close of the summer rainfall season. During this period 523.1 mm or 84 per cent of the mean annual total (621.0 mm) fall on the average, a distribution which is typical for the summer rainfall area.

Periodic droughts, however, particularly in January and February occur almost every season. This is demonstrated by the occurrence of dry spells, those of 7 - 10 days duration being most frequent during the summer rainfall period. Dry spells may extend over 16 - 20 days in summer and over one to five months in winter. The probability of dry spells of 7 - 10 days duration is approximately 60 per cent in each month from October to March. From April onwards the probability of spells of more than 26 days increases and exceeds 60 per cent from June to August.

3. SAMPLING PLOT

Approximately 95 % of the sampling plot is covered with kikuyu grass *(Pennisetum clandestinum)*, the other 5 % being occupied by *Verbena bonariensis* and *Themeda trianda* (plate 1). Kikuyu grass (plate 2) is a perennial creeping extensively by means of rhizomes and stolons. It may reach a height of more than 120 cm but usually it is less than 60 cm high. The grass is native to east tropical Africa but is now cultivated in many parts of the world. In South Africa it is valued as a nutritious palatable fodder plant, and produces a good quality pasture in high rainfall areas. It is also grown extensively for lawns and sports turf, forming a dense, hardy rather coarse sward that grows and spreads rapidly and seldom permits the invasion of weeds. The kikuyu grass on the sampling plot invaded natural pasture more than ten years ago; the natural vegetation probably consisted mainly of the above-mentioned *Themeda* and *Verbena* species.

3.1. **The Soil**

The soil of the sampling plot can be divided into two main layers namely an upper greyish, granular loam layer with an average thickness of 12 inches, and a lower hardy black turf layer. The waterholding capacity of the soil can be described as moderate. The amount of pore-space was not determined but it is probably not favourably for larger animal species to inhabit this soil. The physico — chemical composition of the soil as well as the influence of the kikuyu grass with its extensive rooting contributed to the fact that it may be regarded as a "mull" type.

The mean values of the different analyses of the soil are as follows: pH (H_20 — method), 7 05; pH (KC1 — method), 6 03; P_20_5 (p.p.m.), 468; K_20 (p.p.m.), 4037; Ca0 (p.p.m.), 2625; Na (p.p.m.), 75; Organic material (%), 11.3.

PLATE 1. Kikuyu grass sampling plot.

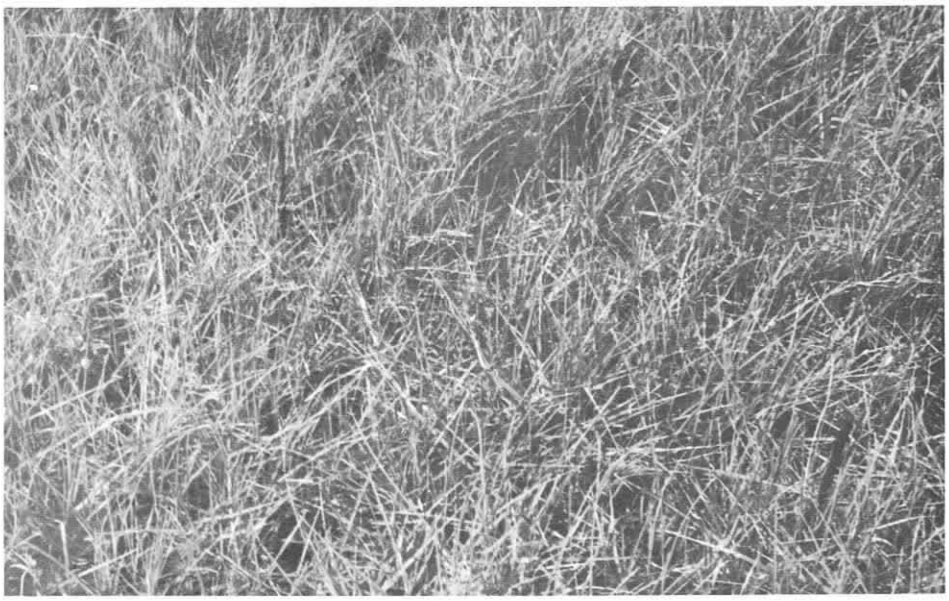

PLATE 2. Close up of kikuyu grass.

3.2. **Temperature**

As temperature variability is extremely important ecologically, the maxima and minima of the air temperatures as well as the soil temperatures recorded at the sampling plot are presented graphically in fig. 1.

An analysis of the temperature data reveals that during the period October 1962 — September 1963 the air temperatures ranged from — 6.1° C (July 24th) to 34.8° C (October 16th). The soil temperatures reached an absolute minimum of 4° C (July 14, 15, 24th) and an absolute maximum of 40° C (December 10th). As can be expected the air temperatures are much more variable than the soil temperatures. The maxima of the air temperatures were lower than those of the soil during the period October — April, but generally higher during the other months.

The minimum temperatures of the soil were always higher than those of the air. The conspicuous drop in temperatures during November and January was caused by the cooling effect of the rains. The mean monthly temperatures of the soil are presented in fig. 4.

3.3. **Rainfall**

The daily rainfall figures (in mm) for the sampling period given in table 1 show that the monthly totals ranged from nil mm in August to 114.8 mm in November and 111.5 mm in January. In comparison with the average monthly figures, the period April to July presents a striking difference. As stated above, the period from October to March can be regarded as the summer rainfall season during which 84 % of the mean annual total fall; the long-term average figures for April, May, June and July are 35.8, 19.8, 7.4 and 8.8 mm respectively. During the sampling period, however, the figures for these months were 81.5, 38.5, 41.9 and 29.0 mm which represent almost 30 % of the rainfall total for the period. These winter rains decidedly influenced the soil community. The rainfall figures are also shown as three-day totals (fig. 4) in the form of histograms.

3.4. **Moisture**

Moisture and temperature are so important in the soil environment and so closely interacting that they are usually considered to be the most important part of the climate. The interaction of these two factors depends on the relative as well as the absolute values of each. Temperature, therefore, exerts a more

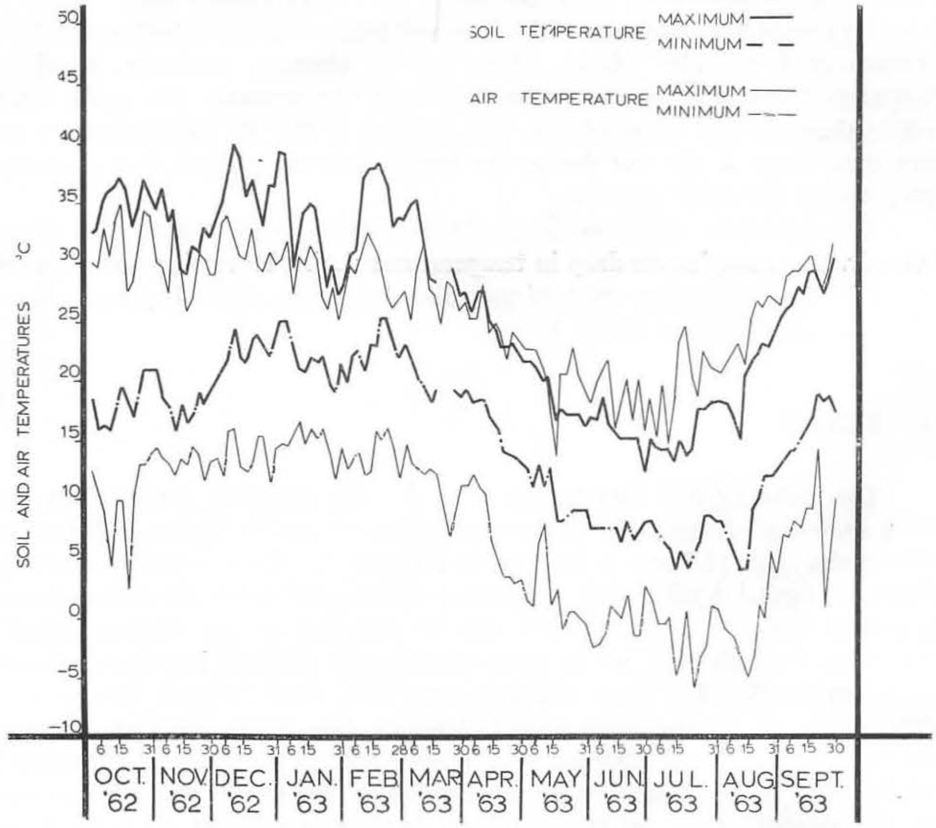

Fig. 1 — Maxima and minima of air and soil temperatures recorded at sampling plot.

TABLE I

DAILY VALUES OF RAINFALL TAKEN AT THE AGRICULTURAL RESEARCH INSTITUTE, POTCHEFSTROOM, OCT. 1962 — SEPT. 1963 (In MM)

S D = SAMPLING DATE

	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEPT.
1	1.0	3.7			13.4					12.0		
2	0.9	2.9				2.3	29.9					
3	3.0	0.8										
4												
5			2.6	12.0			22.5					
6		8.0										
7		16.5				0.9						
8		17.1		2.5			18.8					
9		21.4		0.9				13.4		17.0		
10												
11		1.3		9.1		4.1		3.6	8.4			
12		6.6		1.1		31.2	9.4		11.8			
13		S 7.3 D					0.9					
14		7.7	7.9									
15		7.5		6.2	4.5							
16	S D	12.9	20.5						S D	S D		
17				S D		7.7						
18		1.1				2.5						
19												
20		2.8	S D	30.0	0.9	S D					S D	S D
21	20.0		19	26.3	S D							
22			19.5	0.3	23.7		S D	S D				
23		21.6		0.1								
24		1.0		2.3								
25				10.5		0.9						25.0
26				9.6								
27								21.7	12.9			
28		4.6				10.5			8.8			
29	0.1					0.6						
30												
31	0.3			0.6								
Total	25.3	144.8	52.4	111.5	42.5	60.7	81.5	38.5	41.9	29.0	—	25.0

severe limiting effect on organisms when moisture conditions are extreme, that is, either very high or very low, than when such conditions are moderate. Likewise, moisture plays a more critical role in the extremes of temperature.

The mean of the soil moisture in the sampling plot was 29.832 %, a figure which, however, does not represent the actual average moisture content of soil during the sampling period. The percentages given in table 2 only reflect the moisture content of the soil at the time when the sample was taken. In comparison with European soils our soils exhibit more fluctuations in moisture content, expecially in the top 5 cm during periods when high temperatures prevail. According to Thamdrup (1939) a moisture content of 30 per cent in European soil is regarded as a condition of "severe drought". This author, however, also ascertained that in some instances a soil moisture content of 10 — 20 % may correspond to a relative humidity of 75 — 90 % in the cavities.

TABLE 2

Percentages of soil moisture in upper 5 cm of sampling plot on sampling dates

OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEPT.
07.837	24.768	16.719	35.208	07.856	57.411	16.194	58.610	56.534	54.673	32.188	11.306
08.913	28.406	12.284	34.902	16.925	62.110	33.067	54.857	41.339	55.665	13.571	16.313
04.952	40.616		25.901	06.980	59.866	18.939	21.896	35.185	59.312	18.801	11.313
Mean % 07.234	31.263	14.501	32.003	10.587	59.795	22.733	45.121	44.352	56.550	20.853	12.996

4. METHODS

4.1. **Sampling**

A quadrat of 100 ft^2 (9.2903 m^3) on the farm of the Potchesfstroom Agricultural Research Institute was selected as the sampling plot. The fenced in plot was bordered on two sides by a narrow road; a ditch and an open veld area were situated on its other two sides (plate 1).

For random selection of smaller plots within the quadrate, the area was divided into a hundred subplots each measuring 1 ft^2 (929.03 cm^2). By means of drawing lots 15 subplots were determinated and measured out on the quadrat. Short poles were driven into the centre of each subplot so as to indicate its correct position for sampling. Of the 100 subplots Nos. 4, 11, 16, 19, 25, 26, 38, 43, 53, 54, 59, 90, 93 and 99 were selected. A subsample was taken from each of these 15 subplots on the 16th October 1962, 13th November 1962, 20th December 1962, 17th January 1963, 21st February 1963, 20th March 1963, 23rd April 1963, 22nd May 1963, 20th June 1963, 16th July 1963, 20th August 1963 and 20th September 1963 (table 1).

For sampling 15 brass rings were used, each with an inner diameter of 5.18 cm and a height of 5 cm. The surface area of the cylinder, therefore, was 21.074099 cm^2 and its volume 105.3708 cm^3. To determine the number of animals per m^2 the mean for the totals of 15 subsamples was multiplied by the factor 474.5. As the soil in the sampling area may be very hard during certain periods of the year, brass cylinders which could be forced into the soil were used. The sharp cutting edge of these rings gave minimum resistance during sampling. With the aid of a wooden block and a hammer each sampler was driven into the upper 5 cm of soil on the selected subplots. This was done very cautiously, so as not to disturb the soil of the subsample because special care had to be exercised to penetrate through the extensive root system of the kikuyu grass. By means of a light garden trowel, the sampler containing the subsample was removed from the soil and immediately covered up on both sides of the cylinder with two tin plates (3″ by 3″); the latter were secured by means of rubber rings. The subsamples were subsequently provided with the relevant data and conveyed directly to the laboratory for extraction.

4.2. **Extraction**

The extraction apparatus employed in the course of the present study was a model disigned after the description given by Auerbach & Crossley (1960). This extractor consists basically of a perspex box containing removable trays which accommodate 15 sample containers and 15 funnels. The sample holders are arranged in three five-unit banks separated by perspex partitions. The heat source is provided by means of nichrome wire with a reflector, separate heaters being placed over each bank. The removable trays keep the sets of sample containers in position approximately one inch below the reflectors. Each sample container is held by a perspex insert with a flange which fits into an opening on the tray; the length of the insert is such that the upper half of the sample containers is visible above the tray. The bottom of the perspex insert accomodates a removable circular piece of screen with a one mm diameter mesh size. Immediately below the sample containers a second set of trays holds the small plastic funnels. The collecting vessels stand on sliding trays on the floor of the apparatus. During operation air is fed into the apparatus, by means of a fan, at the lower back wall and it emerges at the upper front. This air circulation prevents condensation in the funnels.

The collecting bottles were filled with 70 % alcohol to which a few cristals of phenol, which prevented contamination by fungi or bacteria, were added.

After removal of the tin plates the brass cylinders containing the subsamples were placed in an inverted position on the funnel's sieve in the sample material; the fact that the sampler rings were used as sample containers also contributed to lessn disturbance of the soil. Some authors prefer to use plastic instead of metal rings because the former is a non-concuctor and therefore should produce a higher temperature gradient. Aucamp et al. (1964), however, determined the gradient in both plastic and brass cylinders by means of a thermocouple galvanometer but could not find any significant difference. During operation of the extractor, temperatures were regulated in such a manner that an initially low temperature (28° C) was gradually increased over the entire extraction period of five days, to reach a maximum of 40° C on the last day. After the collecting bottles were removed from the apparatus the soil particles adhering to the funnels were carefully washed out in containers labelled with numbers corresponding with the bottles; in some instances it was found that numerous mites (especially the smaller specimens) were trapped in the funnels. Although counting the fauna of the sample units was most time-consuming the numbers given in the tables represent absolute counts. Because the mesofauna in our soils was practically unknown when the present investigation started this procedure was found to be necessary.

4.3. **Biomass estimation**

Approximate biomass figures (tables 3 - 6) have been obtained for each species by weighing the specimens on a Sartorius balance. Coverglasses with a diameter of ½" were used as weighing discs. These were thoroughly cleaned, dried over an alcohol flame and weighed. Specimens of each species were transferred onto the coverglass, which was placed on a slide, and observed under a research microscope, using the 10X occulars and objectives. Live specimens were used for the majority of the species.

The animals were collected in water to remove all traces of soil adhering to them and also to prevent them from drying out during extraction. The microscope light served as a heat souce to dry off the excessive moisture from the surfaces of the specimens. Particular care was taken not to desiccate the animals. This was controlled by observing the state of the animals through the microscope and switching off the microscope light as soon as enough moisture had evaporated. The coverglass and the specimens were then transferred to the balance and weighed. According to their size different species were weighed in groups consisting of 40, 20, 15, 10 or 5 individuals. After subtracting the weight of the coverglass the answer was divided by the number of specimens weighed to determine the mean weight of one individual of the particular species. These figures are limited to those species of the mesofauna which penetrated through the 1.5 mm diameter mesh of the extractor. In an attempt to get an indication of the size and nature of the macrofauna, the Moczarski — Winkler extraction apparatus was used.

4.4. **Recording of physical factors**

Temperatures of air and soil (fig. 1), soil moisture (table 2) and daily rainfall (table 1) were recorded during the sampling period. Air temperatures and daily rainfall figures were obtained from the weather station of the Agricultural Research Institute which is situated approximately a ¾ mile from the sampling plot. The soil temperatures were recorded at a depth of 2.5 cm underneath the kikuyu grass by means of a soil thermograph. To determine the soil moisture, three additional soil samples were taken each month. These were dried in an oven at 100° C and the percentage moisture was calculated from the weights obtained before and after drying.

5. COMPOSITION OF THE MESOFAUNA

For the purposes of this investigation the mesofauna can be defined as those animals collected by the funnel method of extraction (1.5 mm diameter mesh) and includes the Arachnida, Myriapod, Insecta and other members of the Arthropoda. The quantitative survey undertaken for this study revealed that the Acari contributed approximately 79 % to the numbers and 30 % to the biomass of the fauna collected during the sampling period, the other arthropods constituting the remaining 21 % and 70 % respectively. The numerical contribution of the Acari was composed of 43.2 % from the Trombidiformes, 31.5 % from the Oribatei and 4.2 % from the Mesostigmata, the biomass being 9 %, 18 % and 3 % respectively. The contribution of the Acaridiae to both numbers and biomass of the mites is negligible. The curves for the total numbers and the biomass of the mesofauna as well as histograms of the biomass of the mite groups and other arthropods for each month are presented in fig. 7.

The Collembola constituted 15.5 % of the 21 % of "other arthropods" and their average numbers per m^2 were 7,457 compared with 37,857 of the

Acari. The ratio Acari / Collembola, therefore, is 5 :1 which is more or less the same as the proportion found by Macfadyen (1952) in fenland. The total mesofaunal Arthropoda collected in the present study averaged 47,996 per m².

5.1. **Trombidiformes**

In table 3 the numbers of the different Trombidiformes belonging to 21 families collected from each sample are given. The total numbers of 19 of these families are shown by means of histograms in fig. 2.

The Tarsonemidae, Pyemotidae and Scutacaridae were not identified below family level. The species collected probably belong to the genera *Tarsonemus, Steneotarsonemus, Pygmephorus* and *Scutacarus.* These Tarsonemini constituted 10.761 % of the total numbers of the mesofauna but owing to their minute size their biomass figure is merely 0.6244 %.

The Eupodidae were represented by three species of the genus *Eupodes,* two of wich *(E. variegatus* Koch, *E. parafusifer* Ryke & Meyer) are known to science. As far as biomass is concerned this family was superior to all the other families of Trombidiformes. Their numbers were 4.757 % and their biomass 2.6357 % of those of the mesofauna totals.

The Linotetranidae *(Linotetranus),* Raphiganathidae *(Raphignathus),* Tetranychidae *(Bryobia praetiosa* Koch) Trombidiidae, Rhagidiidae *(Rhagidia),* Bdellidae *(Bdella)* and Cheyletidae *(Cheyletia)* were each represented by one species only and the number of specimens collected during the entire sampling period varied between 2 and 31. Of these families the greatest biomass (0.0790 g) and highest numbers were provided by the Linotetranidae. The Pachygnathidae were also present in small numbers (29) but they were represented by two genera namely *Bimichaelia* and *Petralychus.* The Erythraeidae with 39 specimens were comprised of more than one species, *Abrolophus bipilus* Meyer & Ryke being known to science. Sixty five specimens of *Molothrognathus* sp., the sole representative of the family Caligonellidae, were collected but these represented only 0.357 % of the total numbers and 0.2486 % of the biomass. The family Paratydeidae *(Scolotydeus)* exceeded one hundred specimens but their numbers were still well under one per cent of the mesofaunal total. The Lordalychidae *(Lordalychus)* reached a total of 229 and the Cunaxidae, represented by the genera *Cunaxa* and *Cunaxoides,* were 497 in number; the former of these two genera was the most abundant. The numbers of the Stigmaeidae (408) were less than those of the Cunaxidae but four different species representing four genera could be distinguished namely *Apostigmaeus navicella* Grandjean, *Ledermülleria* sp., *Cheylostigmaeus* sp. and *Stigmaeus* sp.

The Nanorchestidae were present in numberes exceeding 1700 which were 9.372 % of the total but represented a biomass of only 0.725 %. Although two

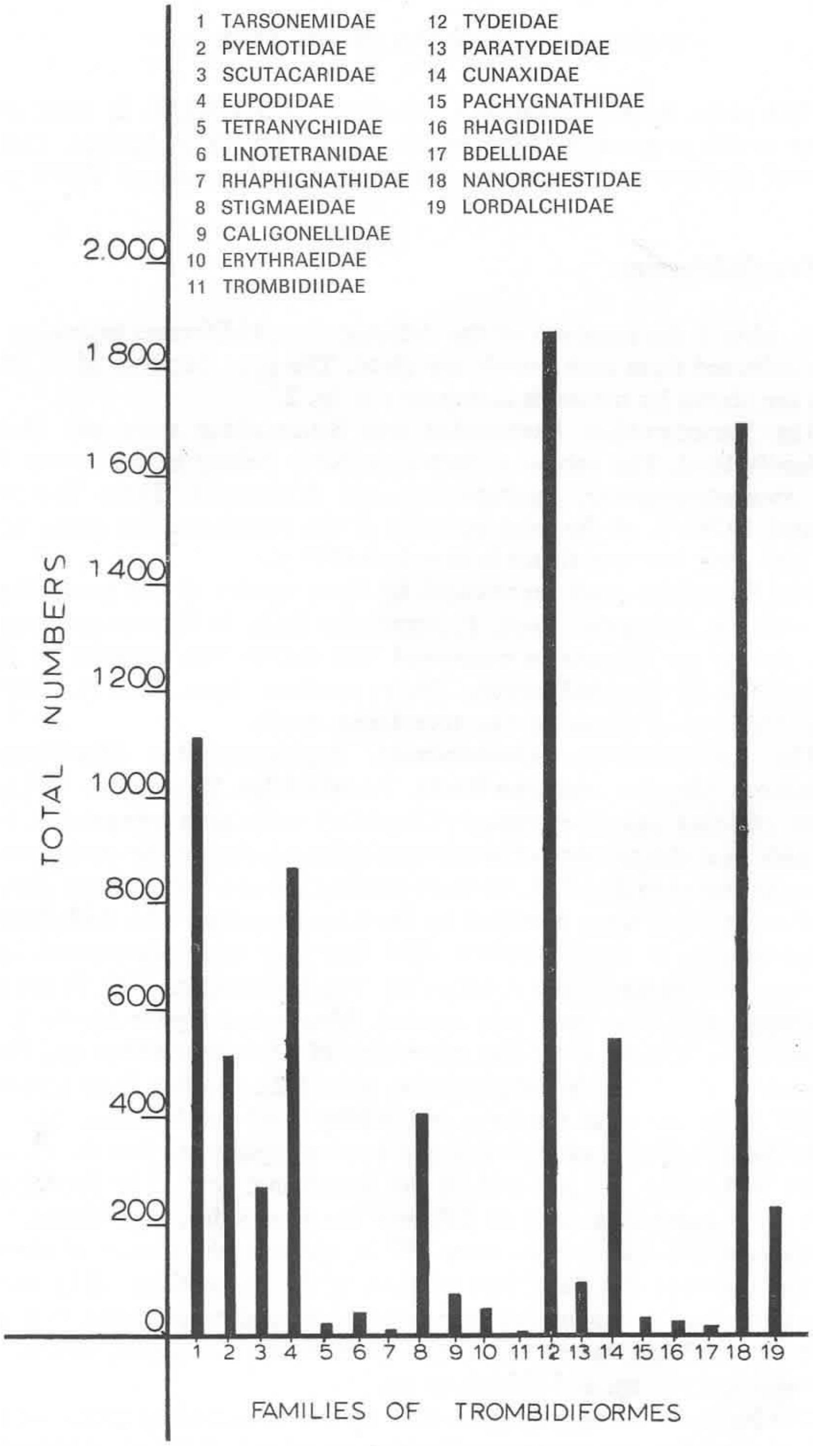

Fig. 2 — Total numbers of the families of Trombidiformes collected during the sampling period.

TROMBIDIFORMES: NUMBERS PER SAMPLE AND PERCENTAGES OF TOTAL MESOFAUNAL NUMBERS AND BIOMASS

	OCT.	NOV.	DES.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOT.	NUMBERS %	BIOMASS %	Mean biomass per Individual (mg.)
Tarsonemidae	37	47	99	75	157	64	75	132	128	249	81	38	1182	6.492		
Pyemotidae	43	66	39	56	74	29	12	28	146	92	16	14	515	2.828		
Scutacaridae	33	—	24	8	18	38	28	21	15	31	44	2	262	1.439		
Tarsonemini *in toto*	113	113	162	139	249	131	115	181	289	372	141	54	1959	10.759	.6244	0.0015
Eupodidae:																
Eupodes sp	10	60	28	50	11	19	29	7	26	57	25	28	350	1.922		
E. variegatus	14	8	15	30	35	25	23	49	62	70	74	28	456	2.393		
E. parafusifer	3	4	—	5	—	4	6	12	11	1	31	3	80	.438		
Eupodidae *in toto.*	27	72	43	85	46	37	38	68	98	128	150	59	886	4.753	2.6350	0.0140
Tetranychidae: *Bryobia praetiosa*	—	3	—	2	4	—	—	1	2	1	2	1	16	.087	.0407	0.0140
Linotetranidae: *Linotetranus* sp.	5	—	—	2	11	—	—	2	—	5	3	3	31	.170	.0790	0.0120
Tenuipalpidae: *Brevipalpus* sp.	—	—	—	—	—	—	—	—	2	—	—	—	2	.010	.0008	0.0020
Raphignathidae: *Rhaphignathus* sp.	—	1	—	—	—	—	—	—	—	—	—	2	3	.016	.0012	0.0020
Stigmaeidae:																
Apostigmaeus navicella	6	—	14	13	28	20	32	37	27	37	36	23	273	1.498		
Ledermulleria sp.	1	4	1	4	6	2	10	13	18	17	18	8	100	.548		
Cheylostigmaeus sp.	2	—	2	2	—	1	—	4	3	3	—	—	17	.093		
Stigmaeus sp.	—	2	1	6	2	—	2	2	1	—	1	1	18	.098		
Stigmaeidae *in toto*	9	6	18	25	36	23	44	56	49	57	55	30	408	2.237	1.5871	0.0160
Caligonellidae: *Molothrognathus* sp.	14	8	7	4	6	2	5	2	3	4	8	2	65	.357	.2486	0.0180
Erythraeidae:																
Erythraeus sp.	—	1	—	1	2	—	1	—	—	—	—	—	5	.027		
Abrolophus bipilus	—	2	—	—	4	—	—	6	3	7	6	5	33	.180		
Erythraeidae *in toto*	—	3	—	1	6	—	1	6	3	7	6	5	38	.207	.3314	0.0400
Trombidiidae	—	—	—	1	1	1	1	—	—	—	—	1	5	.027	.0424	0.0400
Tydeidae:																
Tydeus sp.	13	9	5	40	30	11	23	8	9	12	18	4	182	.998	.5220	0.0135
Coccotydeus sp.	60	31	19	73	108	301	106	132	181	447	178	49	1685	9.254	.5370	0.0015
Tydeidae *in toto*	73	40	24	113	138	312	129	140	190	459	196	53	1867	10.252	1.0590	
Paratydeidae *Scolotydeus* sp..	7	2	2	20	13	18	7	7	11	11	10	4	112	.615	.2855	0.0120
Lordalychidae: *Lordalychus* sp.	1	13	24	50	11	21	24	14	17	12	23	19	229	1.257	.0973	0.0020
Cunaxidae:																
Cunaxa sp.	24	70	50	62	37	37	33	17	23	18	22	23	416	2.283		
Cunaxoides sp.	1	—	6	3	6	13	5	4	11	9	16	7	81	.444		
Cunaxidae *in toto*	25	70	56	65	43	50	38	21	34	27	38	30	497	2.727	1.4785	0.0140
Cheyletidae: *Cheyletia* sp.	1	—	—	—	—	—	1	—	—	—	—	—	2	.010	.0008	0.0020
Pachygnathidae:																
Bimichaelia sp.	—	—	—	1	—	4	—	7	3	4	5	3	27	.147		
Petralychus sp.	—	—	—	—	—	—	—	1	—	—	1	—	2	.010		
Pachygnathidae *in toto*	—	—	—	1	—	4	—	8	3	4	6	3	29	.157	.0985	0.0160
Rhagidiidae: *Rhagidia* sp.	—	1	2	—	2	4	1	2	2	2	3	2	21	.115	.0624	0.0140
Bdellidae: *Bdella* sp.	1	—	—	—	2	1	—	2	2	—	1	—	9	.049	.0267	0.0140
Nanorchestidae:																
Nanorchestes sp.	156	335	156	116	87	67	36	80	122	61	176	38	1410	7.744		
Speleorchestes sp.	1	—	—	—	57	19	29	29	41	55	59	6	296	1.625		
Nanorchestidae *in toto*	157	335	156	116	144	86	65	109	163	116	235	44	1706	9.369	.7250	0.0020
Trombidiformes *in toto*	413	667	497	624	711	701	489	619	769	1305	857	312	7864	43.205	9.1608	—

species were found the main contribution came from the genus *Nanorchestes,* those specimens belonging to *Speleorchestes* being present in insignificant numbers. The family Tydeidae was the dominant family in numbers (10.257 %) and the genera *Tydeus* and *Coccotydeus* contributed to a biomass of 1.0470 %; the bulk of these specimens belonged to the latter genus, the size of which is very much smaller than those of the genus *Tydeus.* Both Nanorchestidae and the Tydeidae had a lower biomass than either the Eupodidae, Stigmaeidae or Cunaxidae.

5.2. **Mesostigmata**

The data of table 4 show that the Mesostigmata were represented by 17 different species belonging to five gamasid families and the Uropodoidea. Numerically the Rhodacaridae were the dominant family with representatives of the genera *Asca, Antennoseius, Rhodacarellus, Gamasellus, Digamasellus* and *Gamaselliphis. Digamasellus badenhorsti* Ryke and *Rhodacarellus* sp. were the most numerous, the former being by far the largest contributor to biomass.

The Laelaptidae included the genera *Pseudolaelaps, Laelaspis, Hypoaspis, Cosmolaelaps* and *Leptolaelaps.* The relatively high biomass figure for *Leptolaelaps elegans* Berlese made a substancial contribution to the total of 1.2908 % for the Laelaptidae.

Although the numbers of the Rhodacaridae (447) were almost three times higher than those of the Laelaptidae (160) the total weight of the former family amountd to only 1.2661 %.

The Phytoseiidae and Aceosejidae were each represeted by one species only belonging to the genera *Amblyseius* and *Lasioseius* respectively. The former species was twice as abundant as the latter but its biomass was less. Only two specimens of the Macrochelidae *(Macrocheles* sp.) *and two of the Uropodoidea* were collected during the entire sampling period.

5.3. **Oribatei**

The oribatei were represented by 18 species belonging to 12 genera (table 5) and nine families. The numbers of the different families are compared in fig. 3. The Oribatulidae were dominant both in numbers and in biomass; this was mainly due to the presence of a large number of specimens belonging to different species of the genus *Scheloribates.* The Opiidae was the subdominant family, the genus *Multioppia* being the largest contributor. They were followed by Cosmochthoniidae *(Cosmochthonius)* and Eremobelbidae (comprising the genera *Eremulus* and *Fosseremaeus).* Althrough the Carabodidae *(Carabodes)* were present in low numbers they made the second highest contribution to the

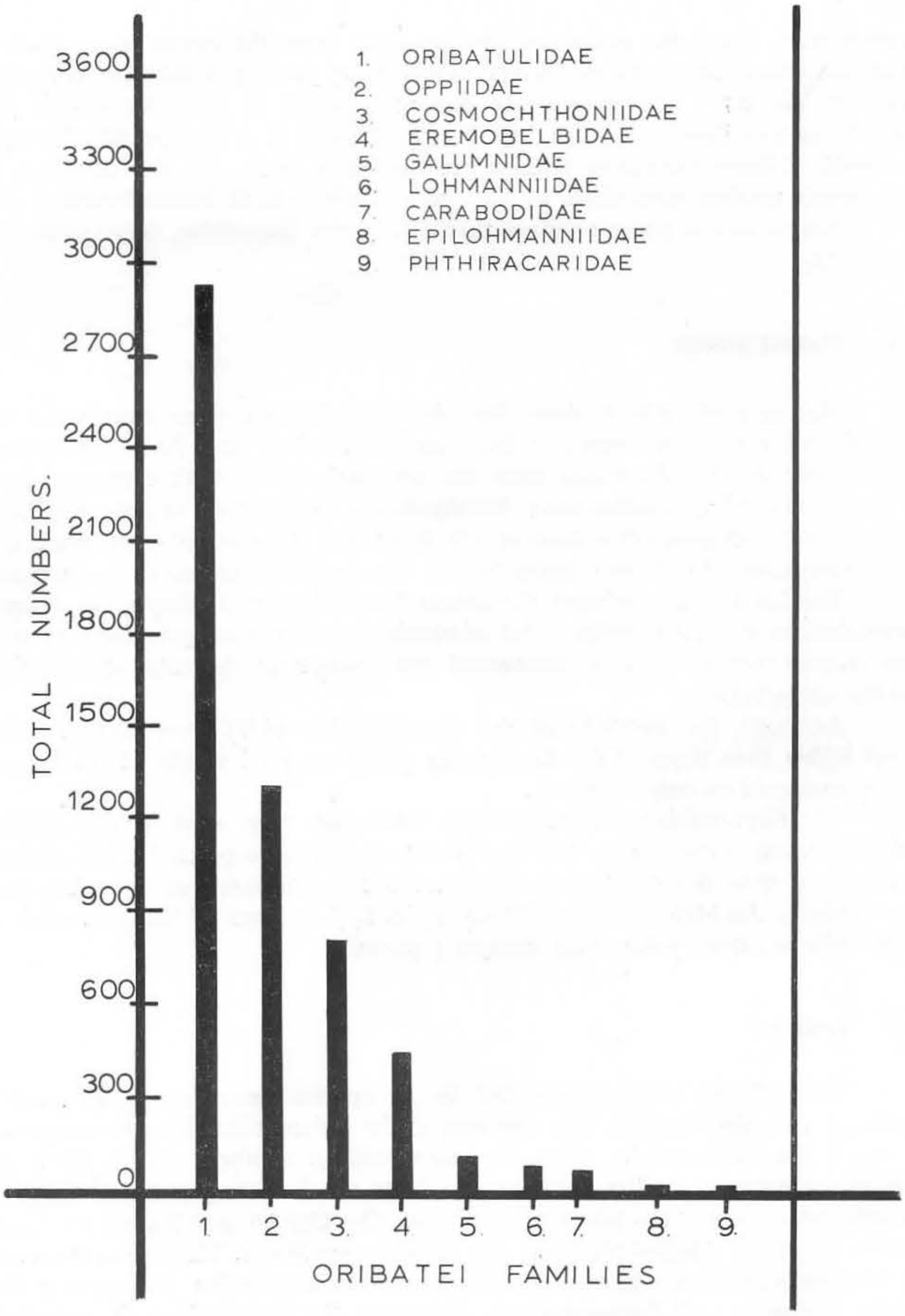

Fig. 3 — Total numbers of the families of Oribatei collected during the sampling period.

TABLE 4

MESOSTIGMATA: NUMBERS PER SAMPLE AND PERCENTAGES OF TOTAL MESOFAUNAL NUMBERS AND BIOMASS

	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOT.	NUMBERS %	BIOMASS %	Mean biomass per Individual (mg.)
Macrochelidae: *Macrocheles* sp.	—	—	—	—	—	1	—	—	—	1	—	—	2	.010	.0084	0.0200
Aceosejidae: *Lasioseius* sp.	2	2	—	13	6	6	6	2	4	4	1	2	48	.263	.2447	0.0240
Phytoseiidae: *Amblyseius* sp.	3	5	7	22	23	4	7	15	3	5	7	3	104	.571	.1767	0.0080
Rhodacaridae:																
Asca sp.	6	3	5	10	2	7	10	5	13	3	2	3	69	378	.3225	0.0220
A. spinosa	1	—	—	—	—	—	—	—	—	2	—	—	3	.016	.0140	0.0220
A. aethiopica	—	—	1	1	1	—	2	—	2	2	—	—	9	.049	.0095	0.0050
Antennoseius boskopensis	—	—	—	—	—	—	—	—	—	—	1	—	1	.005	.0042	0.0200
Rhodacarellus sp.	5	—	13	7	15	19	15	9	13	17	18	10	141	773	.0614	0.0020
Digamasellus badenhorsti.	8	12	14	25	7	23	16	21	20	8	34	26	214	1.175	.8185	0.0180
Gamaselliphis potchefstroomensis.	1	—	—	—	—	1	—	—	—	—	—	—	2	.010	.0055	0.0180
Gamasellus sp.	1	—	1	1	—	4	—	—	—	—	—	1	8	.043	.0305	0.0180
Rhodacaridae *in toto*	22	15	34	44	25	54	43	35	48	32	50	40	447	2.455	1.2661	
Laelaptidae:																
Pseudolaelaps sp.	1	—	1	1	—	7	2	—	2	1	2	—	17	.092	.0650	0.0180
Laelaspis sp.	1	—	—	—	1	—	—	—	—	—	—	—	2	.010	.0084	0.0200
Hypoaspis praesternalis	6	8	2	5	5	5	3	—	2	—	1	—	37	.202	.1572	0.0200
Cosmolaelaps sp.	—	1	—	—	—	—	—	—	3	—	1	—	5	.026	.0084	2.0080
Leptolaelaps elegans	1	5	9	18	3	10	—	14	8	17	14	—	99	.543	1.0518	0.0500
Laelaptidae *in toto*	9	14	12	24	9	22	5	14	15	18	18	—	160	.879	1.2908	
Uropodoidea	—	—	—	—	—	—	—	—	—	—	2	—	2	.010	.0055	0.0080
Mesostigmata *in toto*	36	36	53	103	63	87	61	66	70	60	83	45	763	4.191	2.9919	

TABLE 5

ORIBATEI: NUMBERS PER SAMPLE AND PERCENTAGE OF TOTAL MESOFAUNAL NUMBERS AND BIOMASS

	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOT.	NUMBERS %	BIOMASS %	Mean biomass per Individual (mg.)
Cosmochthoniidae																
Cosmochthonius sp.	1	10	8	31	4	48	55	112	171	189	135	39	803	4 411	.5118	0.0030
Phthiracaridae																
Phthiracarus sp.	—	—	—	—	—	—	—	2	3	2	1	—	8	.043	.0339	0.0200
Epilohmanniidae																
Epilohmannia sp.	2	—	1	—	—	2	1	4	—	—	—	—	10	.054	.0063	0.0030
Lohmanniidae																
Lohmannia sp.	2	—	35	1	4	10	10	1	1	3	3	4	74	.406	.4088	0.0260
Eremobelbidae																
Eremulus sp.	11	—	9	7	25	14	11	—	6	19	24	18	144	.791	.1529	0.0050
Fosseremus spp. (2)	1	15	9	50	20	43	25	40	19	27	35	11	295	1.620	.3133	0.0050
Carabodidae																
Carabodes sp.	1	2	—	—	—	—	6	12	13	19	6	1	60	.329	1.2749	0.1000
Oppiidae																
Multioppia sp.	30	93	173	104	51	227	115	63	116	95	148	31	1,246	6.845	1.3238	0.0050
Oppia spp. (2)	4	—	5	19	5	—	—	13	—	—	—	—	46	.252	.0488	0.0050
Galumnidae																
Galumna spp. (2)	1	3	4	4	18	12	14	6	20	5	14	6	107	.587	.5002	0.0220
Oribatulidae																
Zygoribatula sp.	—	—	3	—	4	10	1	22	8	6	1	2	57	.313	.3633	0.0300
Scheloribates spp. (4)	70	188	352	368	212	277	263	225	291	167	363	103	2.879	15.815	12.9812	0.0352
	123	311	599	584	343	643	501	500	648	532	730	215	5.729	31.466	17.9192	

biomass of the Oribatei. Other families that were also collected are the Phthiracaridae *(Phthiracarus)*, Epilohmanniidae *(Epilohmannia)*, Lohmanniidae *(Lohmannia)* and Galumnidae *(Galumna)*.

5.4. Acaridiae (Astigmata)

Only five specimens of astigmatid mites were collected two of these were recovered from the October sample and one each from the January, June and July samples.

5.5. Other Arthropoda

The arthropods other than the mites constituted approximately 21 % of the numbers and 70% of the biomass of the mesofauna. The numbers collected during each month as well as the percentages of numbers and biomass of the different groups are given in table 6.

The Collembola were the most numerous of the "other Arthropoda" during every month of the year. They constituted more than 15 % of both numbers and biomass. The vast majority of the collemboles were Arthropleona and they were more or less equally divided between the superfamilies Poduroidea (7.284 %) and Entomobryoidea (7.806 %) but the former contributed 10.4251 % and the latter only 4.8311 % to the biomass total. The numbers of the Symphypleona were low (0.45 %) and their biomass reached 0.0696 %.

Only a few larval forms of the Thysanura (11) and Orthoptera (2) and a single specimen of the Anoplura were extracted. The Corrodentia and Hemiptera were represented by 50 specimens but whereas the former had a negligible weight of 0.08 % the latter contributed 3.9098 % to the mesofaunal biomass. A relatively high number (122) of Homoptera, represented by the Pseudococcinae, were collected. Although only 65 specimens of the Thysanoptera were found their contribution of 5.5 % to the biomass was higher than any other of the pterygote insects. The Diptera (53) and Coleoptera (41) were represented by both adult and immature stages and their biomasses were 3.1873 % and 1.6701 % respectively. Three hundred and sixty four ants (Hymenoptera) made a contribution of approximately 5 % to the biomass of the mesofauna.

The mites and insects together constituted nearly 99 % of the numbers of the mesofauna but their biomass total was only 65.6 %. The remaining 34.4 % of the weight was provided by the Chilopoda, Pauropoda, Araneida and Crustacea. The Chilopoda (73), which were all members of the family Geophillidae, made the substantial contribution of 30 % to the mesofaunal biomass. Only one specimen of the Crustacea was collected. The non-arthropods were confined to 76 nematodes which constituted 0.417 % of the numbers and 0.0968 of the biomass of the mesofauna collected by means of the funnels.

5.6. **The Macrofauna**

The above-mentioned mesofauna penetrated through a 1.5 mm mesh. In an attempt to determine the nature of the macrofauna, material from the litter layer was collected for extraction by means of the Moczarski-Winkler apparatus. The animals collected included surface dwelling Lepidoptera larvae, adult Diptera and Hymenoptera, numerous soil inhabiting Coleoptera with measurements up to 12.0 mm × 6.0 mm, and Hemiptera measuring up to 18.0 × 4.0 mm. Less frequent animals were forms such as Araneida (11.0 × 5.0 mm) and the crustacean *Oniscus* (6.0 × 2.0 mm).

Interesting to note is that not a single earthworm was found in the soil, whereas in European soils they make out a large proportion of the animal biomass. Bornebush (1930), for instance, recorded a total faunal biomass of 70.8 g, 53.0 g consisting of earthworms. The absence of earthworms is not due to the extraction process used because several earthworms were extracted from swamp soil by means of funnel batteries.

6. NUMERICAL FLUCTUATIONS OF ACARI AND COLLEMBOLA

The seasonal quantitative differences in the soil fauna may be attributed partly to differences in the activities of the animals (e.g. migration) and partly to real frequency fluctuations (e. g. reproduction). For a causal explanation of fluctuations in the numbers of the soil mesofauna it is therefore necessary to have a knowledge of their reproduction, developmental periods, life spans and the influence of abiotic environmental factors. Very little is, however, known of the ecology of the different species. It is therefore only possible to try and correlate these fluctuations with physical factors such as temperature, water content and rainfall.

It is evident from the graphs in fig. 4 that there was a marked difference in the size of the acarine and collembolan faunas at different times during the sampling period. It is, however, doubtful whether the same picture would be repeated every year. To facilitate the recognition of correlations with temperature and rainfall, these factors are represented by the graph and histograms in the figures. The mean monthly numbers of Acari and Collembola per m^2 are plotted against the mean monthly soil temperatures and the rainfall totals for each three-day period are depicted in the form of histograms.

When making deductions from the data given in fig. 4 it should be borne in mind that only the upper 5 cm of the soil was investigated. In European soils it is generally the case that the majority of the microarthropods inhabit this layer. A number of supplementary samples extending from 6-10 cm,

TABLE 6

MICROARTHROPODS (excluding Acari): NUMBERS PER SAMPLE AND PERCENTAGES OF TOTAL MESOFAUNAL NUMBERS AND BIOMASS

	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOT.	NUMBERS %	BIOMASS %	Mean biomass per Individual (mg.)
Collembola	59	345	239	327	106	168	107	189	208	373	477	231	2829	15.540	15.3258	0.0190
Thysanura	—	2	4	4	—	—	—	—	—	—	—	1	11	.060	.2337	0.1000
Orthoptera	—	—	—	—	—	1	—	—	1	—	—	—	2	.010	.1912	0.4500
Corrodentia	—	—	5	1	16	11	3	1	1	1	1	—	40	.219	.0849	0.0100
Anoplura	—	—	—	—	—	—	—	—	—	—	1	—	1	.005	.0004	0.0150
Hemiptera	4	—	—	8	2	7	5	13	4	2	1	—	46	.252	3.9098	0.4000
Homoptera	—	1	38	7	21	6	31	11	3	2	—	2	122	.670	.4018	0.0155
Thysanoptera	—	3	7	6	2	2	11	14	7	9	3	1	65	.357	5.5247	0.4000
Diptera	—	4	2	2	—	2	20	3	3	4	13	—	53	.291	3.1873	0.2870
Coleoptera	1	4	6	3	2	2	3	5	3	5	4	3	41	.225	1.6701	0.2100
Hymenopera	20	20	40	46	94	48	24	38	8	3	2	21	364	1.999	4.9037	0.6340
Chilopoda	1	12	11	1	5	15	5	4	9	3	6	1	73	.401	30.2479	1.9500
Pauropoda	4	1	1	2	22	12	11	9	9	7	14	11	103	.565	.3939	0.0180
Araneida	—	—	3	—	5	2	1	3	3	1	1	—	19	.104	3.0279	0.7500
Crustacea	—	—	—	—	—	—	—	1	—	—	—	—	1	.005	.7118	3.3500
	110	392	361	409	298	277	224	291	259	410	532	283	3846	20.712	69.8158	

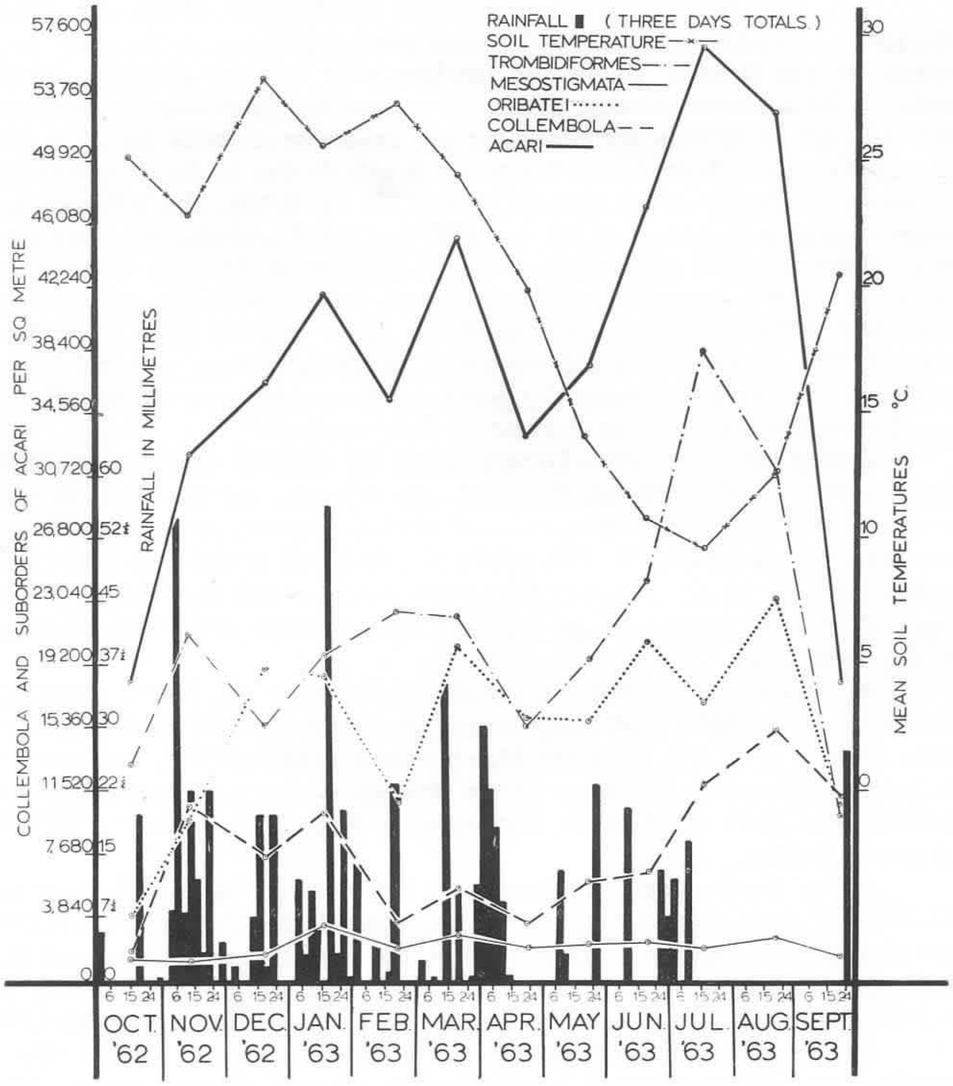

Fig. 4 — Monthly fluctuations in numbers of the Acari and Collembola and recorded physical factors; rainfall histograms representing three-day totals.

however, indicated that the lower layers may accommodate more animals, especially when the surface layer becomes desiccated and parched by the sun. This condition probably results in a downward migration of some organisms.

It is clear that the population increases and decreases of the mite orders during the sampling period show the same general tendency as the group as a whole. In the October sample the numbers were low for all three orders, followed by a general increase during November. An interesting phenomenon, however, occurs between the November and December sampling date. The rise in numbers of the Acari during this period is entirely due to the sharp increase in population density of the Oribatei (from 9,838 to 18,948). The Mesostigmata made a small contribution (1,139 to 1,676) but the Trombidiformes decreased from 21,099 to 15,722 per m^2. The decline in numbers of the latter group might be the result of a downward migration of some species caused by the exceptionally high soil temperatures (reaching 40° C, fig. 1) and the low soil moisture content. The Mesostigmata and especially the Oribatei were probably better equipped to survive this warm dry period in the oupper layer of the soil and could therefore maintain the increase in their numbers.

During the December — January period the numbers of all groups, with the exception of the Oribatei, increased. The February sample which showed a general decline of the mites and collemboles, however, contained a larger number of Trombidiformes. This might be attributed to the fact that 1 mm rain fell during the day preceding the sampling date so that only the superficial layer of the soil became damp; the small trombidiform mites have returned to the upper 5 cm.

A comparison between the samples of February and March shows an increase in the numbers of all groups except the Trombidiformes which decreased from 22, 491 to 22,175. Since the March sample contained 60 % moisture, it is possible that some specimens of the delicate species were trapped in the funnels. The lower numbers of trombidiforms may therefore be a reflection of poor extraction.

In the April sample a reduction in the numbers of both Collembola (3,385) and Acari *in toto* (33,246) was recorded; during the preceding period the mean temperatures were relatively low, the rainfall was adequate and the soil moisture content was relatively high. It is therefore rather difficult to explain this reduction in population numbers on the basis of the available data.

During May, June and July both the Acari the Collembola increased rapidly. The Trombidiformes reached their highest density during July (38,118) whereas the Oribatei and Collembola occured in higher numbers in the August sample. Whether these winter maxima are characteristic of conditions in this geographic area is open to doubt. It seems reasonable to suggest that these peaks were produced by the extraordinary amount of rain which fell during these months. It could also be correlated with the high moisture content of the soil, the low temperatures and the resultant slow evaporation of water. These presented conditions which were optimal for the mesofauna. The insulating function of the kikuyu grass blanket was probably responsible for the fact that the Collembola and Oribatei reached their peaks during August even though no rain fell during a 42-day period before this sample was taken (table 1). Even the numbers of the Trombidiformes were still very high.

As a result of the sharp increase in temperatures and the low soil moisture content, the September sample shows a dramatic decline in the numbers of especially the Trombidiformes. Bearing in mind the fact that not a drop of rain fell during a period of more than 70 days before the September sample was taken, the number of Collembola (7,307 per m^2) collected is remarkable.

6.1. **Trombidiformes**

A comparison between the population increase and decrease of the two most important (with reference to numbers) families namely the Tydeidae and the Nanorchestidae (fig. 5) leads to the following interesting observations and deductions. The numbers of the Nanorchestidae were already relatively high during October (4,334), but showed a substantial increase to 10,597 in November; this was followed by a population decrease reaching 2,056 in April, with a slight flare up during February (4,555). The Tydeidae, on the other hand, started at a relatively low level in October (2,309) and the numbers gradually decreased to the December minimum (9789); a subsequent rise in their numbers culminated in a first peak during March (9,870) followed by a decline in April (4,081). The populations of both families increased slightly in size during the next two months but, whereas the Tydeidae reached their second and highest peak during July (14,520) the numbers of the Nanorchestidae fell back to a level slightly above that of the May sample. The former family decreased in numbers during August but the Nanorchestidae reached their second highest peak during this month. It is therefore noteworthy that these two families never occurred in high numbers during the same period, a phenomenon which might suggest the existence of a possible negative interspecific relationship between a species of the genus *Coccotydeus* (Tydeidae) and the genus *Nanorchestes* (Nanorchestidae).

The Tarsonemidae are numerically the third most important family. As depicted in fig. 5 their numbers rose from 1,170 during October to 4,966 in February (which are higher than those of both the Nanorchestidae and the Tydeidae) reaching a peak of 7,877 during July. Other families which occurred in smaller numbers are the following: Cunaxidae, Bdellidae, Rhagidiidae, Pachygnathidae, Paratydeidae, Trombidiidae, Erythraeidae, Caligonellidae, Rhaphignathidae, Linotetranidae, Tetranychidae, Lordalychidae, Scutacaridae,

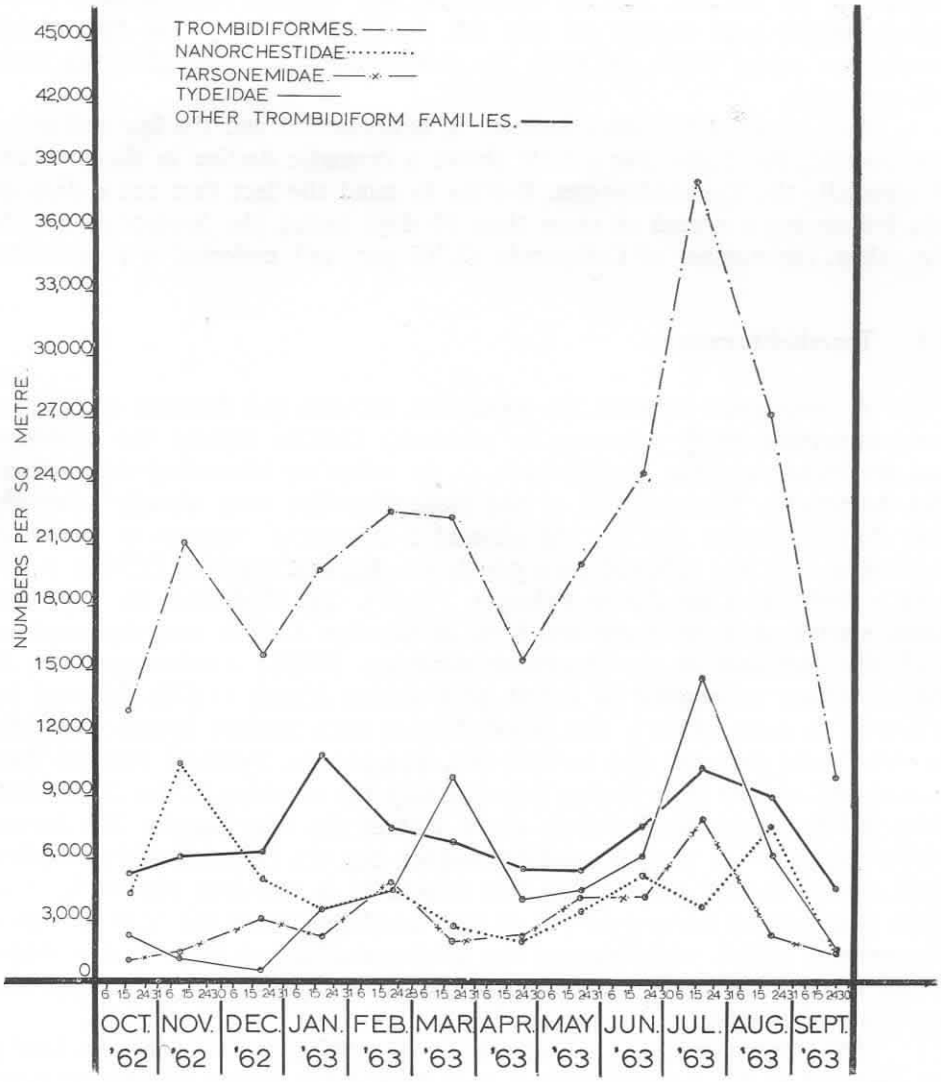

Fig. 5 — Monthly fluctuations in numbers of the families of Trombidiformes.

Stigmaeidae and Pyemotidae. The majority of the members of these families are, however, rather associated with the soil surface or the bases of the kikuyu grass stems than with the soil proper.

6.2. **Mesostigmata**

The numbers of this group were the lowest of the three orders but their lack in numbers was balanced by their higher biomass fiigures. The Mesostigmata totalled 1,139 in both October and November but the species combinations were different (fig. 6). The November total was mainly the result of an increase in the numbers of Laelaptidae (from 285 to 443) and a decrease in the numbers of Rhodacaridae (696 to 475). December showed a general rise which was largely due to an increase in the numbers of the Rhodacaridae (1,012). The Mesostigmata reached a peak during January as a result of the presence of 1392 Rhodacaridae, 759 Laelaptidae, 696 Phytoseiidae and 411 Aceosejidae. The period between January and February exhibited a drop in the numbers of all the families except the Phytoseiidae which remained at a constant level. Both the Rhodacaridae (1,708) and the Laelaptidae (695) however, reached a peak during March, whereas the other two families decreased to under 200 specimens per m^2. The densities were lower in April but during the following month the Laelaptidae and Aceosejidae increased in numbers. The Rhodacaridae reached a third peak in June (1,518) and a fourth in August (1,740). The numbers of the Laelaptidae also remained relatively high from June to August but showed a subsequent sharp decline during September. The Phytoseiidae and Aceosejidae collected from samples during the period June to September seldom exceeded the 200 mark. The Rhodacaridae therefore were decidedly the dominant family of the Mesostigmata throughout the year. The only other family which was occasionally collected from the soil is the Macrochelidae. Since the majority of the Mesostigmata are predacious, it can readily be assumed that they do play their part in the fluctuations in population densities of other mite groups.

7. BIOMASS FLUCTUATIONS

The data presented in fig. 7 illustrate the fluctuations of the biomass of the mesofauna as compared with fluctuations in numbers. From the histograms it is clear that the biomass was largely determined by the arthropods other than the mites. These other arthropods were mainly Collembola, but whereas this insect order reached maximum abundance during August the biomass figure for the group as a whole was low. Its highest value was reached during February when the numbers of the mesofauna were relatively low (44,761 per m^2). This is due to the fact that a large proportion of the fauna consisted of small mites.

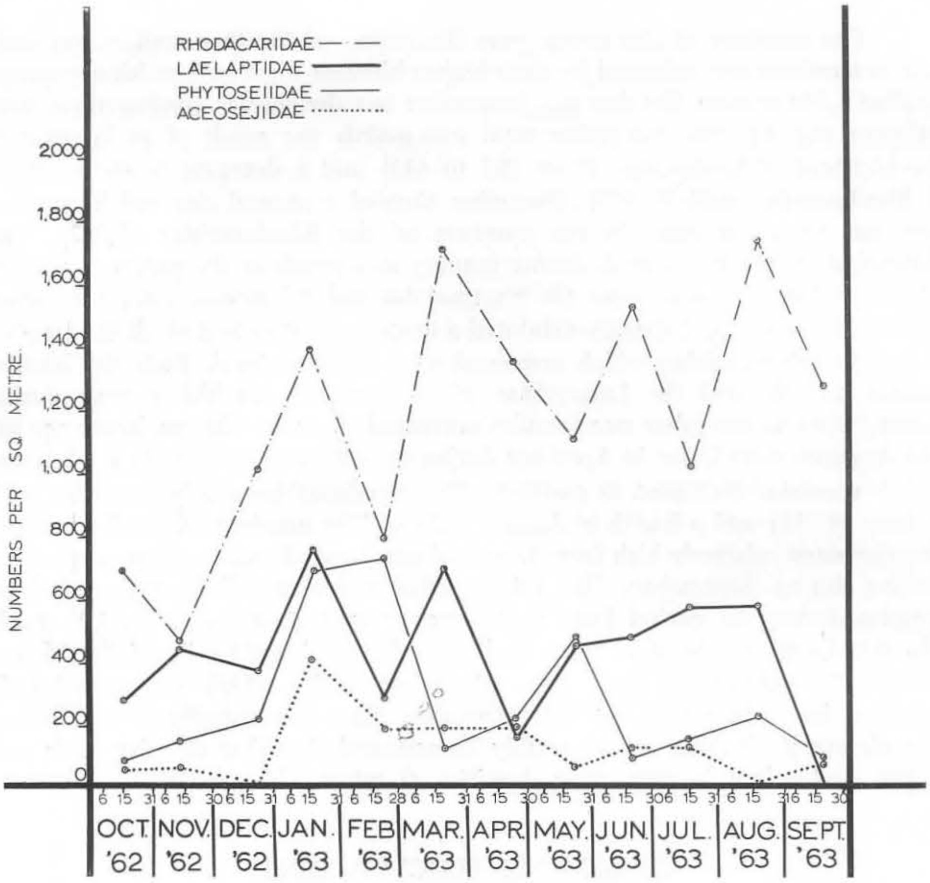

Fig. 6 — Monthly fluctuations in numbers of the families of Mesostigmata.

The seasonal fluctutations in biomass of the Acari *in toto* more or less closely follow those of the numbers. The rise in numbers during the period between the June and July sampling dates, however, was not accompanied by an increase in biomass. During the following month this condition was reversed and a decrease in numbers is coupled with an increase in biomass. Both these phenomena were almost entirely determined by the number of Oribatei present at those times.

A comparison between the relative positions of the main microarthropod groups with regard to numbers and to biomass (fig. 8) reveals the following: Both in respect of numbers and biomass the Mesostigmata were the smallest group of the three main suborders of the mites. The Trombidifomes were the most abundant group but they occupied the second lowest position in the biomass graph.

With reference to weight the Oribatei were undoubtedly the dominant group of mites. In this respect they were, however, surpassed by the Collembola during the months of November, January, July, August and September. The fact that during certain periods the numbers of the different groups rose whereas the biomass dropped, is the result of a increase in the numbers of the smaller species and a decrease in those of the larger ones.

When the values of biomass and numbers of the families of the Trombidiformes are compared it becomes clear that the positions of the numerically important Tydeidae, Nanorchestidae and Tarsonemidae were very much lower than that of the other families lumped together. The numbers of the Tydeidae, for instance, were higher than those of these "Other families" during March and July. In respect of biomass figures, however, the values for the "other families" were twice as high during March and five times higher during July.

When the biomass figures of the families of Mesostigmata are compared with their numbers it is evident that the Rhodacaridae did not maintain their dominant position; this is largely due to the presence of the relatively heavy specimens of *Leptolaelaps elegans* which resulted in a sharp rise in biomass of the Laelaptidae during January, March and July. In the March sample the biomass figure for the Laelaptidae is almost three times higher than that of the Rhodacaridae. Both in numbers and biomass the Aceosejidae, Phytoseiidae and Macrochelidae were far below those of the other two families.

8. HORIZONTAL DISTRIBUTION OF MESOFAUNA

In table 7 the figures of the number of animals collected from each subsample during every month of the sampling period are presented. An analysis of these figures reveals that the mesofauna was more or less evenly distributed over the sampling plot. This can largely be attributed to the relatively even

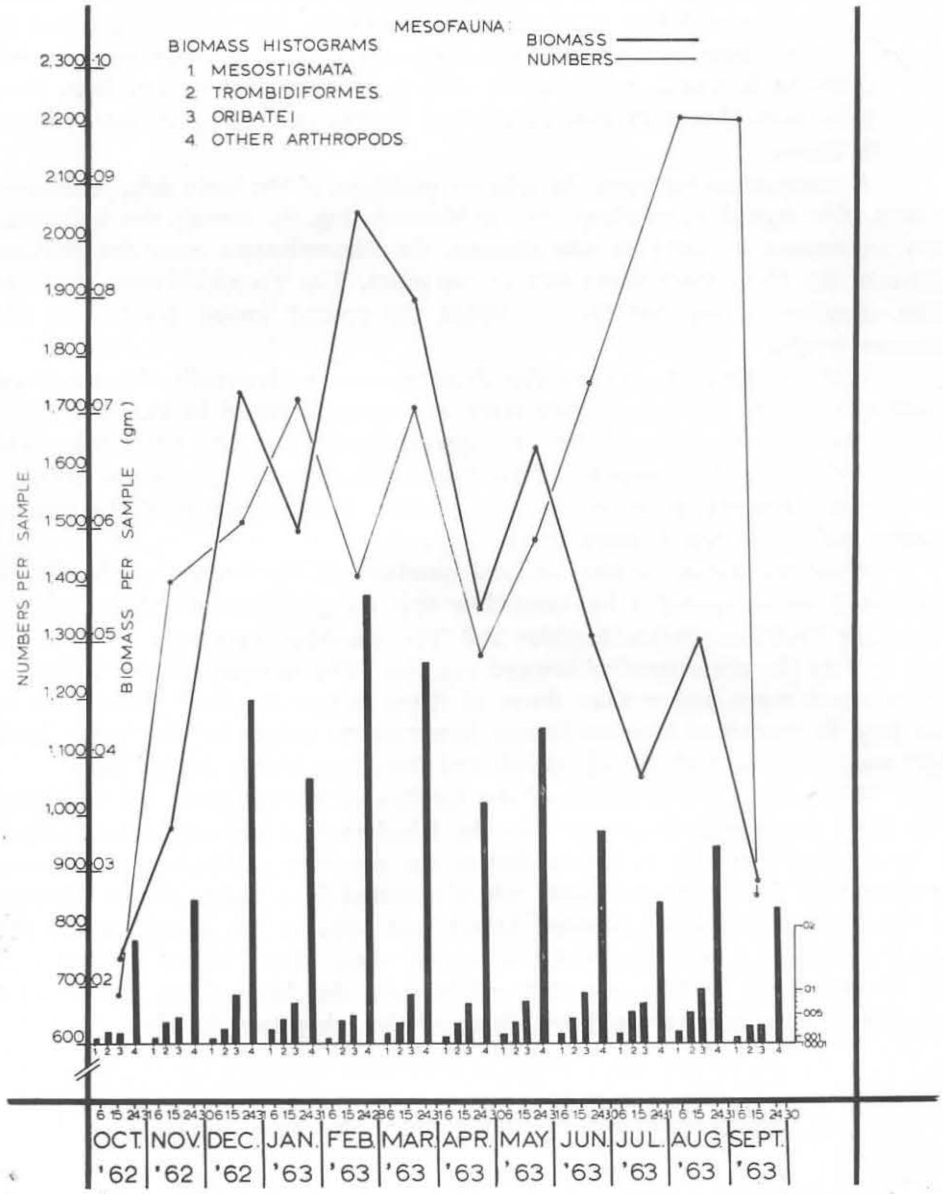

Fig. 7 — Monthly fluctuations in biomass of the microarthropods (mesofauna).

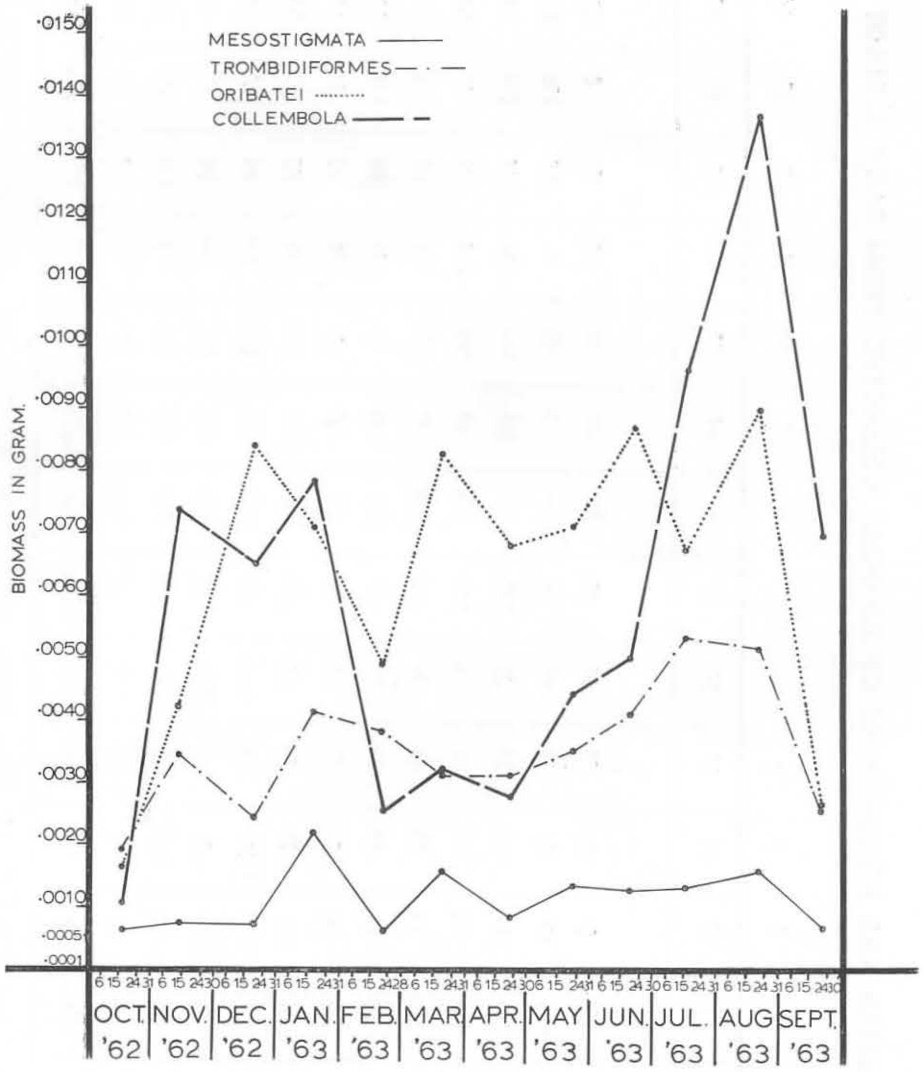

Fig. 8 — Monthly fluctuations in biomass of the mite orders and the collemboles.

TABLE 7

NUMBERS AND PERCENTAGES OF ANIMALS COLLECTED FROM EACH SUBPLOT

SUB-SAMPLE No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
SUB-PLOT No.	4	11	16	19	25	26	38	43	44	53	54	59	90	93	99	
MONTH																TOTAL
Oct. 1962 . . .	28	84	38	70	36	55	23	88	47	51	46	31	8	71	8	684
Nov. 1962 . . .	81	81	136	25	70	81	38	159	72	95	86	23	138	214	107	1,406
Dec. 1962 . . .	50	205	81	47	54	27	143	77	101	111	139	116	104	149	106	1,510
Jan. 1963 . . .	95	154	95	70	97	114	100	73	84	185	106	106	67	223	152	1,721
Feb. 1963 . . .	70	216	44	29	88	39	69	78	137	52	59	87	78	305	64	1,415
Mar. 1963 . . .	99	105	89	97	74	93	113	207	138	90	123	80	141	127	132	1,708
Apr. 1963 . . .	130	113	96	35	72	78	79	97	89	131	78	39	36	119	83	1,275
May 1963 . . .	31	157	101	75	88	76	132	146	161	132	45	62	72	165	33	1,476
Jun. 1963 . . .	78	130	108	139	70	110	57	174	103	278	99	86	62	200	53	1,747
Jul. 1963 . . .	142	231	154	121	192	101	177	308	113	117	94	70	60	85	243	2,208
Aug. 1963 . . .	120	226	106	152	75	221	104	219	168	165	50	222	49	249	76	2,202
Sept. 1963 . . .	18	54	82	85	55	37	77	100	59	69	12	13	7	153	34	855
	942	1,756	1,130	945	971	1,032	1,112	1,726	1,272	1,476	937	935	822	2,060	1,091	18,207
Percentages . . .	5.1738	9.6446	6.2064	5.1903	5.3331	5.6680	6.1075	9.4798	6.9863	8.1067	5.1463	5.1353	4.5147	11.3143	5.9922	

growth of the kikuyu grass over the entire quadrat. Subplot no. 90 yielded the lowest percentage (4.51 %) and no. 93 (11.31 %) the highest. On subplots nos. 4, 19, 25, 26, 54, 59 and 90 the grass covering was less dense and this probably contributed to the fact that their percentages were the lowest. Subplots nos. 11, 43, 53, and 93 had a richer grass covering and the softer loam soil and higher percentage of organic material were possibly responsible for denser populations occurring on them. The other subplots (16, 38, 44 and 99) were in an intermediate position).

The coefficients of variation for each month calculated from the data of the 15 subplots are presented in table 8. Ford (1938) found that the beginning of the season, with low population numbers was accompanied by a decrease in the variability but an increase in population numbers was accompanied by a decrease in the variability. This phenomenon he attributed to the uneven distribution of the vegetation and the rapid evaporation of moisture from the bare patches during the dry season. The more dense grass areas retained more moisture and could accommodate larger populations of the mesofauna.

TABLE 8

Distribution of fauna on plot: coefficients of variation

MONTH	MAX.	MIN.	X	S. D.	C. V.
Oct. 1962 . . .	88	8	45.60	24.0	52.631
Nov. 1962 . . .	214	23	93.80	157.2	167.590
Dec. 1962 . . .	205	27	100.66	143.4	142.459
Jan. 1963 . . .	223	67	114.73	140.5	122.461
Feb. 1963 . . .	305	29	94.33	226.2	239.790
Mar. 1963 . . .	207	74	113.86	101.7	89.315
Apr. 1963 . . .	130	35	85.00	30.2	35.541
May 1963 . . .	165	31	98.40	144.2	146.545
Jun. 1963 . . .	278	53	116.46	187.5	160.999
Jul. 1963 . . .	308	60	147.20	216.3	146.942
Aug. 1963 . . .	249	49	146.80	211.7	144.209
Sept. 1963 . . .	153	7	57.00	120.9	212.105

From the figures in table 8, however, it is evident that during the dry month of October 1962 (7 % soil moisture) the C. V. was low, which is just the opposite of Ford's observations under European conditions. This could readily be explained because all the populations were much depleted.

The great diversity in the coefficients of variation might have been due to aggregation because the low C. V.'s cannot always be correlated with decreases in population density. Differences in the soil moisture content of the different subplots certainly would have contributed to variability. The efficiency of the extraction process for recovering the small specimens, especially from wet samples was probably also a factor which played a role in this connection. The new ghrease film technique developed by Aucamp & Ryke (1964, 1965) might prove to overcome this problem.

9. DISCUSSION

The variation in seasonal abundance of the soil mesofauna has been the subject of several investigations in Europe. In these northern temperate regions the microarthropod population undergoes a marked seasonal fluctuation which usually involves minima during the summer months and maxima during the autumn and winter (Evans et al., 1961). In the present study it was found that the mite population fell to a minimum during the September — October (spring) period with a subsequent rise in density which resulted in a first peak during February and March (late summer) and a maximum during the winter (June-July). It can readily be assumed that this winter peak was to a large extent due to the unusual amount of rain which fell during the autumn and winter months. The long-term average total for the four months April-July is 71.8 mm, 16.2 mm of which being the amount for June and July together. During the sampling period, however, 70.9 mm of rain fell during June and July and this phenomenon must have had a great influence on the fauna of the upper 5 cm of soil. Whether the mite population would reach a peak under "normal" conditions is open to doubt.

From the results obtained during this investigation it can therefore be deduced that the low temperature and relatively high moisture content of the soil, created optimum conditions for the mites and collemboles. (It is, of course, well known that under European climatic conditions the microarthropods are generally so insensitive to low temperatures that they can be frozen in the soil and after thawing out re-assume their activity again).

Evans et al. (1961), Macfadyen (1952) and Sheals (1957) came to the conclusion that the Oribatei are much more subjected to seasonal fluctuations than the Mesostigmata. The first mentioned authors reported that the Prostigmata follow the same general trend as that of the Oribatei and they are of the opinion that the fluctuations, especially those of the cryptostigmatid populations, are closely connected with the reproductive cycles of the mites. Haarlov (1960) however, maintains that these fluctuations are mainly due to changes in ecological conditions. From the available data it seems reasonable to suggest that ecological factors play an important role in determining population densities in our soils.

The present study of the composition and seasonal changes in the soil mesofauna is part of the first full scale investigation of the conditions in African soils. No data are available of studies which were undertaken in soils with similar climatic conditions. The only soil samples which were collected in Africa to determine the number of arthropods are those collected by Salt (1953, 1955) in Kenya, Tanganyika and Uganda. According to this author these investigations were exploratory in nature and few samples could be thoroughly studied in the time avaiable. Unfortunately he does not give an analysis of the composition of the Acari but treated them as a group. In Uganda Salt (1955) took six samples of soil under elephant grass *(Pennisetum purpureum)* and (with the flotation process) extracted approximately 23,200 mites and a total of 73,517 arthropods per m^2 from the top 6 in. of the soil; the numbers in adjacent cultivated ground were much lower. The samples collected from soils in Kenya and Tanganyika (1953) under different grasses yieled less numerous arthropods (38,417 per m^2) than those in Uganda.

In the Potchefstroom samples the numbers of the mites in the kikuyu plot fluctuated between a minimum of 18,157 per m^2 during October 1962 to a maximum of 56,876 during July 1963. These figures are possibly not comparable with those of Salt since he probably would have lost a large percentage of the smaller mites (especially Trombidiformes) in the flotation process. When these figures from African soils are compared with those from European grasslands they are much lower since some authors collected even hundreds of thousands per m^2 (Salt et al., 1948; Macfadyen, 1952; Murphy, 1953; Haarlov, 1960 a.o.).

The Oribatei are, almost without exception, the dominant group of mites in European soils. Hughes (1959) maintains that this is the case in all soils. The above-mentioned data show that numerically the Trombidiformes were the superior group during all the seasons. In forest soils in the United Kingdom the Trombidiformes are in second position and the Mesostigmata in the third position but in grassland and other soils the numbers of the former group are usually much lower than those of the other two main orders (Evans et al., 1961).

Mainly because of taxonomic difficulties both the Mesostigmata and the Trombidiformes have not been studied to the same extent as the Oribatei. Available data suggest that the soil Mesostigmata usually possess a high degree of ecological plasticity because similar communities occur in a large variety of soil types. With the exception of *Rhodacarellus* and *Digamasellus* this group is hemiedaphic in nature.

The mesostigmatid fauna of the local soil differs from that in Europe in that the Rhodacaridae are the dominant group and not the Parasitidae, Veigaiaidae or Laelaptidae.

The Trombidiformes are the least known of all the soil mites and they are very difficult to extract successfully. The majority of the genera which occur in European soils were also found in the kikuyu soil. Evans (1951) for example recorded extremely large numbers of *Nanorchestes arboriger* (Berl.) from the floor of a Sitka spruce forest in the United Kingdom. No evidence could, however, be found in the literature that the Prostigmata were numerically in a dominant position in the Northern Hemisphere as is the case in this soil. Di Castri (1963), however, presents data from steppe soils in Chile in which the Prostigmata are more abundant than any other group of mites. A striking difference from our local soils, however, is the absence of the Tarsonemini in those soils.

The ratio of 1 :5 between Collembola and Acari in the kikuyu soil is similar to conditions encountered in European soils. Haarlov (1960) gives a summary of figures extracted from recent publications and the ratios in six grasslands range between 1 :1.5 and 1 :5.5. The presente material suggests that the ratio of Oribatei and Collembola would differ from the European conditions because the former group is not the dominant group in our soils. The accounts of these ratios in the literature are contradictory and Haarlov notes that this situation is not surprising since in the various studies different species of these comprehensive systematic groups are involved.

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